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# EVALUATION OF ELECTRIC POWER DEVELOPMENT POLICY IN TURKEY

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# EVALUATION OF ELECTRIC POWER DEVELOPMENT POLICY IN TURKEY

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## 1. INTRODUCTION

The main purpose of this paper is the evaluation of Electric power development policy in Turkey. In order to achieve this aim past and present situation of electric power and organization problems in Turkey have been briefly explained. Tables given in Section 3 clearly show progress made in Turkey in the field of electric power. River basin development planning is very closely related to electric power planning because of main source of electric power production is hydro power. Special importance is given to appraising of hydro power projects. Methods of economic analysis have been briefly explained. Fimally principles of a sound electric power development policy has been discussed.

## 2 - PAST AND PRESENT STATUS OF ELECTRIC POWER IN TURKEY

The first commercial electric power station in Turkey was put into operation in Tarsus in the year 1902. This was a Hydro-electric power station. After this although many small power stations were installed in various towns and cities, the First World War, War of Independence and following internal troubles affected greatly on the economy of country and so caused to slow down in the development of Electric power in the country until 1930. After 1930 a recovery in the Electric power field was noticed as in the other sectors of economy. But unfortunately this lasted until 1940. During the Second World War and following 2-3 years another great pause was observed. At last some improvement was witnessed in 1948 and especially in 1950 onward. In the period between 1930 and 1948 the power stations were small isolated units consuming valuable fuels such as petroleum and bituminous coal. But in the period from 1948 and especially 1950 onwards large capacity regional power stations were constructed and a tendency to build interconnected networks in the country was observed. Also lignite replaced Bituminous coal and Hydro-electric power was used which is abundant in Turkey. The tables below may explain the case better.

TABLE I - INSTALLED CAPACITY in KWs

| Year | Thermal | Hydro | Total |
|---|---|---|---|
| 1940 | 209,946 | 7,019 | 216,965 |
| 1945 | 235,962 | 9,976 | 245,938 |
| 1950 | 389,896 | 17,885 | 407,781 |
| 1955 | 573,515 | 38,118 | 611,633 |
| 1960 | 860,528 | 411,904 | 1,272,432 |
| 1961 (M) | 881,200 | 462,023 | 1,343,223 |

TABLE 2 - ELECTRIC POWER PRODUCTION in 1000 KWHs

| Year | Thermal | Hydro | Hydro(percentage) | Total |
|---|---|---|---|---|
| 1940 | 383,004 | 13,894 | 3,5 | 396,898 |
| 1945 | 504,046 | 23,762 | 4,5 | 527,808 |
| 1950 | 759,524 | 30,100 | 3,8 | 789,624 |
| 1955 | 1,490,668 | 89,150 | 5,6 | 1,579,818 |
| 1960 | 1,813,661 | 1,001,410 | 35,6 | 2,811,071 |
| 1961 (M) | 1,773,500 | 1,276,500 | 41,9 | 3,050,000 |

TABLE 3 - ELECTRIC POWER CONSUMPTION in 1000 KWHs

| Year | Domestic | Industry | Traction | Total |
|---|---|---|---|---|
| 1940 | 64,727 | 276,810 | 7,812 | 359,349 |
| 1945 | 76,852 | 365,862 | 16,294 | 459,008 |
| 1950 | 152,060 | 508,821 | 17,925 | 678,806 |
| 1955 | 335,021 | 992,363 | 19,866 | 1,347,250 |
| 1960 | 605,705 | 1,751,464 | 38,551 | 2,395,720 |
| 1961 (M) | 660,000 | 1,910,000 | 40,000 | 2,610,000 |

TABLE 4 - TOTAL POPULATION, ELECTRIFIED POPULATION PRODUCTION PER CAPITA

| Year | Population (1000) | Electrified Population (1000) | Per Capita Production(kWh) |
|---|---|---|---|
| 1945 | 18,790 | 3,970 | 28 |
| 1950 | 20,947 | 4,811 | 38 |
| 1955 | 24,111 | 6,540 | 65 |
| 1960 | 27,810 | 8,597 | 101 |
| 1961 (M) | 28,602 | 8,950 | 107 |

TABLE 5 - POWER TRANSMISSION AND DISTRIBUTION LINES (in Km)

| Year | 154 kV | 66 kV | 33 kV | 26-15 kV | Total |
|---|---|---|---|---|---|
| 1940 | - | - | 14 | 105.8 | 119.8 |
| 1945 | - | - | 77 | 105.8 | 182.8 |
| 1950 | - | 98.6 | 77 | 105.8 | 281.4 |
| 1955 | 267.4 | 259.4 | 328.5 | 184.8 | 1042.1 |
| 1960 | 2038.3 | 851.4 | 728.4 | 447.8 | 4065.9 |
| 1961 (M) | 2113.3 | 931.4 | 743.9 | 447.8 | 4236.4 |

(M) Provisional Figures

Studying these tables one draws the following conclusions:

i. The electric power that was used mainly for lighting now is being used largely in industry.

ii. A great tendency to use Hydro-electric resources has been observed.

iii. Especially in the recent years a development towards a regional interconnected network system was observed. This made it possible for many load centers to draw power from the network which is fed by all the power stations in the region concerned. For this purpose a great deal of overhead lines have been constructed.

iv. In spite of all these rapid developments the fraction of population that makes use of electricity is only about 30 o/o. For the year 1961 the average production of electricity per capita is only 107 kWh.

v. No steps towards electrification of villages have been taken.

## 3 - ORGANIZATION IN ELECTRIC POWER

The main organization dealing in electric power is the Ministry of Industry. But some other Ministries and certain departments under these Ministries take part also in the Electrification of Turkey. To give a better idea of the type of work done by these establishments the following table is arranged:

TABLE 6 - ORGANIZATIONS IN ELECTRIC POWER

| Nature of Work | Ministries | | | | | | Others | | |
|---|---|---|---|---|---|---|---|---|---|
| | Industry | | | Public Works | Reconst. and Settlements | | | | |
| | Dept. of Power | Electric Power Resources Survey and Planning Adm. (E.I.E) | Etibank | State Hydraulic Works D.S.I. | Dept. of Planning | Iller-bank | Municipalities | State Economic Enterprises | Private Enterprises |
| Regulation | ++ | - | - | - (Hydro only) | - | - | - | - (Own use) | - |
| Survey | - | ++ | - | ++ | ++ | + | - | - | - |
| Planning | + | ++ | + | ++ | ++ | + | - | - | - |
| Design | - | ++ | ++ | ++ | - | ++ | - | - | - |
| Const. | - | - | ++ | ++ | - | ++ | ++ | ++ | ++ |
| Operation | - | - | ++ | ++ | - | ++ | ++ | ++ | ++ |

++: Does the work +: Partly does the work -: None

As it is seen from Table 6, 3 ministries and many departments have taken part in electrical works. Some acts of the Parliament imposed certain duties on these establishments. But these acts became in adequate due to rapid development of electrification, therefore, some establishments took parts not exactly in accordance with the law which created a bigger problem leading to difficult situations such as duplications etc. This has many disadvantages as:

i. Misuse of already short technical personnel.
ii. Difficulties in the co-ordination of duties.
iii. The difficulties in establishing the degree of priorities of investments.

On the other hand the tendency of producing electric power from water resources creates the problem of finding the most efficient use of these resources with respect to irrigation, power and flood control.

Due to the fact that the responsibilities of flood control and irrigation and of electric power production fall to different hands, difficulties will no doubt arise in coming years.

In recent years reconnaissance and construction of all power plants and overhead lines excluding water resources, and also operation of Interconnected Network System was considered to be given to a single establishment. Eventually a Bill on this subject has been prepared. But a Bill which does not give any importance to water resources in electric power production may later create greater difficulties in organization problems.

## 4 - ELECTRIC POWER RESOURCES

The resources used in the production of electric power are divided into two parts:

a) Fossil Fuels
b) Hydro-electric power

In the last ten years a great development of Hydro-electric power resources was noticed with a respective decrease in the use of Fossil fuel resources. The reason of this decrease is due to poorness of Turkey with respect to these Fossil fuel resources. Following paragraphs explain the situation of these resources:

BITUMINOUS COAL: At present there is only one place producing bituminous coal. Many investigations to find richer mines unfortunately failed. Further studies on the present mine show a capacity of 10-13 billion tons of coal. And the present rate of production is 7 million tons per year. This is because the coal layers are thin and immersed in very low levels. Scarcity of bituminous coal makes its price to go above the general price levels of the country. Production of bituminous coal is just enough for manufacturing coke to be used in metal extraction processes. Because of these reasons the use of bituminous coal in production of electrical energy is decreasing. To see this change one only has to notice that in 1950 bituminous coal was used in 55 o/o of plants producing electric power, in 1961 this figure became 12.3 o/o.

LIGNITE : Almost everywhere in Turkey Lignite mines have been found. Some of these mines contain lignite of high calorific value. Unfortunately none of these mines are rich. In all the surveys made up to now one can not find a lignite mine with a total capacity greater than 150 million tons. The total lignite reservation in Turkey's mines comes out to be about 1 billion ton. But it is hoped from Geological studies of Turkey that some quite rich mines can be found. The present rate of production of lignite is about 3 million tons per year. Beside water resources lignite is also taking the place of bituminous coal in electric power production. Transportation of lignite over long distances is less economical than power transmission.

Also building power stations at the mines using lignite makes the mine operation flexible and efficient. Because of this reason while producing 16 o/o of electric power from lignite in 1950, this figure went up to 19 o/o in 1960.

There is another kind of fuel of low calorific value called Washery left coal. It is possible to use this as fuel in power stations. In 1950 11.5 o/o of power production was obtained from such stations. This figure raised to 24 o/o in 1961.

PETROLEUM : In spite of the fact that a search for petroleum is going on in a large scale the results are not very optimistic. The total crude oil production of Turkey is only enough for about 17 o/o percent of Turkey's need. The rest of remaining Turkey's need is being imported as crude oil. Capacity of present refineries in the country is about 5 million tons per year. The heavy fuel oil that is going to be produced in these refineries can be used in electric power production as well as other industrial needs. Soon a Thermo-electric station using 400.000 tons heavy fuel oil per year, will be installed in Istanbul.

HYDRO POWER : In contrast to poorness of Fossil fuel deposits, Turkey has great possibilities in the field of Hydro-electric power production. Possibility of irrigation and flood control make these hydro-electric projects attractive. According to a survey made in 1955 in cooperation with experts from European Economic Commission the gross hydro-electric potential of Turkey was found to be about $536,535 \times 10^6$ kWh per year. Also according to this survey again $105,150 \times 10^6$ kWh/year of this potential can be developed economically. This gives the percentage of economically possible hydro-electric potential to gross hydro-electric potential to be about 20 o/o. This figure in special cases can go up as high as 40 o/o, such as along some parts of Fırat (Euphrates) River which contributes alone to the gross potential an amount of 105,000 $10^6$ kWh/year.

The distribution of Hydro-electric potential is shown in the table below:

| Region | : Gross Hydro-electric Potential in $10^6$ kWh |
|---|---|
| East Black Sea Coast | 91,515 |
| Eastern and South-Eastern Anatolia | 164,599 |
| Mediterranean Coast | 164,242 |
| Other Regions | 116,179 |

The regions where the potential is the densest are Black Sea Coast and some parts of Western Mediterranean Coast. Eastern Black Sea Coast and especially basin of Fırat (Euphrates) River have high densities. If a line drawn across

Turkey from North to South dividing the land into two equal parts. Then 60-65 o/o of Hydro-electric potential falls into the Eastern region. Specially along the Fırat (Euphrates) River it is possible to obtain great blocks of power. For example building three dams on the Fırat (Euphrates) River it is possible to produce 20-21 billion kWh/year of electric power. Also the possibility of irrigation by these dams make these projects rather attractive. However, today 80 o/o of electric power production is consumed in the Western and North-western part of Turkey. But in these parts there is not great hydro-electric potential. It is necessary to develop the hydro-electric potentials in Eastern and Southern Turkey and transmit the power to the Western part of the country. Latest surveys have shown that producing and transmitting power from the Fırat River basin to Western Turkey is very economical. Also the presence of Iron, chromium and copper mines in Eastern Turkey shows the possibility of using this cheap power for heavy industry, in its place of production.

## 5- ELECTRIC POWER PLANNING

a) Basic Principles in Planning: Planning in the field of electric power depends largely on economic factors. But these are not the only factors in the final decision. Social considerations may play an important role in final decision in some cases.

As it is seen from practice that the factors determining electrical planning can not be estimated closely in a less developed country. For example, neither the effect of supplying cheap and abundant electric power to a region, which uses power for small industry and lighting, can be predicted easily nor can one find the change in demand accurately. Factors effecting the planning of an electric power system may change drastically in newly developing countries. Economics of such countries are not in regular nature and their governments have to take decisions at regular times so electrification is affected.

In Turkey in many cases plants being built with the consideration of sufficiency for 7 or 8 years become inadequate in their second years of operation.

Although electrical investments are heavy burden, the industries employing electricity have investments 3-10 times more. Therefore, in cases of vague determination of necessary power it is more profitable to install electric power supplies beyond the capacity of the present demand.

Also the slogan "Electrical power creates its own market" has been justified with many examples from newly developing countries.

After an explanation of above manner the main principles of Electrification of Turkey may be outlined as follows:

i- Interconnected networks must be substituted instead of isolated power systems.
ii- Needs must be supplied with a margin as large as possible without breaking the harmony in general investments.
iii- In the determination of priority of installations importance should also be given to best possible use of natural resources and other factors like social fundamentals.

b) Relation to National Planning: National Planning in Turkey is a very new subject. The purpose of national planning is to obtain an optimum rate of economical development by developingthe sectors of economy harmoniously. Electrical power has linkage with all economical sectors. Any lack of items in the investment of electric power field will surely have a negative effect on all other sectors of industry. Another difficulty also arises from the impossibility of importing electrical energy in contrast with other field of industry. Therefore, greater care is being given to electrification and the problem of determining the effect of electrical investments on the safety of other industrial fields.

c) Relation to River Basin Development: In Turkey most electrical power production sources will be hydro power in very near future. Today hydro-electric power

production is about 41.9 o/o of total annual electric power production. The Hydro-electric portion in total production will be about 80 o/o in the next ten years. On the other hand irrigation and flood control are very important subjects in Turkey. The utilization of water resources for multiple purposes such as irrigation, flood control and power makes projects attractive in most cases. For example, any single purpose of water power project may not be economical but for multiple purpose use, may become economical.

However, to find the best solution of a water resource project, especially when the number of utilisation purposes increased, becomes very complicated. It becomes necessary to study the case carefully, in detail. Due to this fact Hydro projects are not considered individually but the river basins are generally studied as a whole in order to obtain the harmony among the various purposes. The final selection of hydro power projects for meeting the future power demands is made after the river basin development studies are completed, as it is explained before.

As it can be understood, it is rather difficult to apply this ideal solution to every case.

The chances of knowing the possibility of water sources in every detail and in advance are very few in less developed countries. On the other hand, generally, speaking the fast development rate of the needs of electricity and the other needs narrows the path of the possibility of studying the case in a large scale. In this case it becomes evident to be satisfied with the known possibilities in order to confront the demands on time.

## 6- APPRAISING OF POWER PROJECTS

There are various methods of appraising the power projects. To select a certain method is generally dependant on the type of the problem. The appraisal of the projects is usually the economical comparison of various alternative solutions which meet the needs. The common methods are:

- Unit price comparison
- Rate of return on investment
- Benefit Cost analysis

On some cases, rate of return on additional investment method is also used.

The interest rate is usually considered 7 o/o in the calculations and the comparison period is the useful life of the installation. The comparison is made on infinite life basis as infinite renewal, where the useful lives are different while comparing the alternative plans. These alternative plans are also compared from the point of labour, taxes, and additional activities created in the other sectors.

a) Forecasting power market requirements : The forecasting power market requirement is one of the most important features while appraising an electrical project. It is a well known factthat the forecasting of power demand in a less industrialized country is more difficult than an industrialized and economically stable country. In case of over forecasting, then more investment is being made on electric sector and this creates an excess capacity. On the other hand under forecasting, results a shortage of electric power to the other economic sectors, which experiences harm to overall economic development. Experiences are proved on electrical systems that a small over invesment is better than an under investment which creates difficulties to the other sectors. Due to all these facts, the electric power requirement forecastings are based on several alternative assumptions especially on the long range planning . It is generally considered whether those plans are flexible on these alternative assumptions and could the necessary changes be made in future years.

The demand forecasting is usually a forecasting of the requirements of the existing customers and the requirements of the possible future potential customers.

The studied region is considered from the stand point of its social and economic conditions and natural resources. Generally, the forecastings are revised every other year.

b) Methods of Establishing Priorities of Alternative Schemes: Establishing the priorities for the alternative plans for interconnected systems are as follows:

i- Forecasting power market requirements
ii- Preparing alternative plans for power production facilities and taking into consideration of meeting demands.
iii- Preparing plans for power transmission for every production plan.

Then investment, operation and maintenance expenditures of every plan will be estimated for a certain period of time. This period is not less than 15 years. Expenditures have been actualized using different rate of interests with this calculation it is possible to find present worth of expenditures of alternative plans for different rate of interests. If a choice made for the rate of interest then one of the plans will have minimum present worth of expenditures using this interest rate.

It is also possible to make comparison of plans taking the differences of expenditures and actualizing the plus or minus differences. The rate of interest used in this process which gives the result almost zero is the rate of return on difference of investment of plans compared. The final choice of investment plan is made not only taking into account above calculations but consideration is also given use of local labor, material, national resources and foreign currency requirements.

c) Benefit Cost Criteria for Medium and Large Hydro Projects: These criteria have been extensively used in the river basin development studies in Turkey. As it is explained before hydro power, irrigation, flood control are closely linked together in many projects. In order to obtain maximum benefits from projects, Benefits and costs for each purpose of the project have been estimated. This estimation has been based on:

i- Irrigation benefits: Additional incomes created from changes of crop pattern and amount of crop due to irrigation taking into consideration of additional costs of irrigation etc.

ii- Flood Control Benefits: This is based mainly on average yearly damage done to the area protected.

iii- Power Benefits: Power benefits are measured using an alternative source of power. It is usually a thermal power project which has same capacity with project power feature. Project yearly firm energy and dependable power are evaluated seperately using equivalent thermal power plant fixed yearly operating cost (Interest, amortization and fixed part of operations and maintenance cost) as the capacity, charges and variable operating cost such as fuel, lubricating oil and variable part of operation and maintenance cost as the energy charges.

If benefits from irrigation and power are increased by the years of operation depending upon increasing demand, future benefits have been actualized using an interest rate about 7 o/o . On the other hand, expenditures of investment and operation of the project is also estimated and actualized.

Now it is possible to calculate ratio of benefits to costs of alternative solutions of the project.

Instead of choosing the project which gives the highest benefits cost ratio but one is selected which gives maximum benefits. This has been determined using incremental benefit cost ratios. When incremental benefit cost ratio is 1 this point gives the maximum benefits.

Benefit cost criteria is also used for single purpose medium and large hydro projects for the determination of coefficient of evaluation of the project. In this case the benefits are not calculated using an equivalent thermal plant but a modern thermal plant in large capacity for the whole network. This way it is possible to find relative values of hydro projects. The ratio of benefits to costs is called "Coefficient of value" of the project. This ratio gives an idea bout priority orders of different projects.

d) Economic Criteria Used for Selecting Transmission Lines: The principle of the method used for selection of transmission lines is to minimize the total of cost of installation and actualized losses over total life of line per Km, variables are being cross section and voltage of the line. The losses of the line are separated as peak power losses and yearly energy losses. Calculation of peak power losses is simple, variables in this calculation are cross section and voltage of the line.

Calculation of energy losses depends not only on these variables but also depends on "loss load factor" which is calculated from load factor and the shape of annual load curve. Some studies made for calculation of "loss load factor" showed that this factor mainly depends on load factor. The effect of the shape of annual load curve is very little. Another difficulty arises when the load of the line changes from one year to another due to increased demands. In this case, calculations made for finding a constant load which gives economical equivalent losses over the life of the line. This equivalent load is called "Effective load". In order to obtain Effective load tables have been prepared based upon different rate of interest and different rate of increase and decrease of the load. The interest rate mainly used in this calculation is 7 o/o,

The peak power losses are evaluated using capacity charges of a thermal power plant and energy losses are evaluated using fuel charges of a modern thermal power plant. These charges are adjusted according to network condition. Both losses are actualized and added to the installation cost of line per Km. However selection of transmission line voltage is done taking into account of transformer stations also.

In the case of isolated hydro stations the losses are not evaluated if water available is more than the demand. The evaluation made after assuming certain date of connection to main system.

## 7 - MAIN PRINCIPLES OF A SOUND ELECTRIC POWER DEVELOPMENT POLICY FOR TURKEY

a) Basic Principles of a Sound Electric Power Development Policy for Turkey: In spite of great efforts made on electric power production transmission and distribution in last decade, there is much more work to be done. Today in Turkey only 11% of total population makes use of benefits of electric power. The remaining parts which are substantially villages are not electrified at all.

The need of a rapid economic development necessitates a rapid development of electric power. Furthermore Turkey's fossil fuel resources are not rich, in coming years country will probably depends on solely hydro power which is abundant. The experience gained in Turkey for the development of electric power, up to now puts up the basic principles of electric power policy such as:

i- To build countrywide interconnected power system as fast as possible
ii- To supply electric power to the places before the demand forces its use.
iii- To encourage the public for the widespread use of electricity.
iv- To give special importance of development of water resources for power and irrigation.

b) Basic Principles of Reorganization: As it is explained before there are many organizations in electric power field in Turkey. The duties of these organizations are somewhat over lapping.

The reorganization in Electric power is inevitable for the rapid development of electric power. Otherwise the rate of development will be slowed down. The status of natural resources, and existing organizations in electric power create somewhat different reorganization problem from the other countries. Today in Turkey almost all power fields are in the hands of state and municipal organizations. State organizations are mainly interested in power production and transmission, Municipal organizations are mainly interested in distribution. These Municipal organizations are also involved in public transport, water supply and gas works. On the other hand Hydro power in Turkey is very closely linked with irrigation.

The principles of a good reorganization can be put down with a careful study of today's problems. These are:

i- To establish a single organization with responsibilities of power and water planning, construction and Operation. This organization should not deal with the distribution.

ii- Distribution of power should be responsibilities of Municipal and rural organizations.

iii- Municipal organizations involved simultaneously in power, water supply, Public Transport and Gas Works such that a single organization should deal with electric power only.

iv- To increase the capacity of financing of Municipal Bank for the financement of Municipal and rural organizations.

v- The rate policy should be established such that encouragement of the public for the widespread use of electricity and enough margin for auto financing will be realized.

## 8- CONCLUSIONS

Electric power in Turkey is a promising field of development. Much progress have been done in this field in the last decade. But still more efforts are needed. Turkey's natural resources are very promising especially in water resources which are the heart of agricultural and industrial development.

In order to realize the total electrification all efforts should be unified. To achieve this first priority should be given to reorganizing water and power establishments.

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